

**BEST AVAILABLE COPY**

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakhstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

## **METHOD AND APPARATUS FOR REPAIRING OPTICAL DISCS**

### **Technical Field**

This invention relates in general to repairing a damaged optical disc, and more particularly to an improved abrasive/buffing wheel that facilitates a substantially  
5 uniform application of force to the surface of the disc to remove scratch damage, and a method using the improved abrasive/buffing wheel in conjunction with a non-abrasive means that, when used preferably in a substantially dry manner and under sufficient pressure, generates sufficient heat to cause the material of the surface of the disc to flow and remove fine scratches induced by the abrading/buffing step.

### **BACKGROUND ART**

Optical discs are currently used in a variety of ways, including digitally storing computer data, musical compilations or software within the disc. The information  
10 stored within the disc is protected by at least one layer of material in such a way that the information may still be read by a laser. Specifically, hundreds of millions of pits are molded into one side of a transparent plastic disc. The pits are arranged so that music  
15 or other information is digitally stored in the pits in a helical or spiral pattern, similar to the grooves on a vinyl record. A thin reflective coating or layer is applied to the back of the pits. A protective plastic layer is applied over the reflective layer to protect the coating and the pits. Then a label is applied to the protective layer.

20 The information stored in these optical discs is read by using one or three laser beams that enter the disc through the transparent plastic (i.e., the "play side" or "read side"). The laser is then reflected back from the reflective layer and passes back

through the transparent plastic layer or play side of the disc. When three lasers are used, one reflected laser beam contains the digital information from the pits and is then processed through a device such as a computer, a stereo or a game console. The other two reflected laser beams are used to focus the laser and keep it "on track" as it reads the spinning disc. When only one laser beam is used, the laser reads the data, focuses the laser and keeps the laser on track. In the case of a compact disc, the first track, called the "lead-in" track is a band of data that contains the table of contents for the whole disc. The information in the lead-in track is used by the disc player to quickly locate selected individual songs or other data tracks. Thus, if a person were to select track six on a compact disc, the laser would find the location of track six from the lead in track and then move to that particular location on the disc.

When the play side of the transparent layer is scratched or dirtied, the laser beams may scatter or deviate from their correct optical path as they enter or exit the transparent layer. Such scattering can preclude the proper reading of the data layer. In the case of a compact optical disc, if the tracking beams are scattered, the disc player's closed-loop feedback system might be induced to "thinking" it is off track. It will then try to adjust by jumping either forward or backward. If the player jumps forward, it will "skip" a portion of the music. If the player jumps backward, it will attempt to play until the laser reencounters the scratch and skips backward again. In this way, a portion of data can be repeated indefinitely, causing an obnoxious electronic sound with some players and silence with others. If a scratch limits the readability of the lead-in track, none of the tracks will play because the player would not know where the individual tracks were located.

If only the free surface on the read side of the transparent plastic layer is scratched, the data itself is not harmed. Only the ability to read this data is hindered. Because some disc reading devices allow for the disc to be read even if the transparent layer has certain types of scratches, scratches in optical discs do not necessarily have to be removed completely for a flawless playback. In particular, the size and orientation of the scratch damage to the disc may influence the effect it has on the readability of the disc. For instance, a disc reading device will have a better chance at reading a disc with

a radial scratch than a circumferential scratch. A radial scratch would generally be better because the lasers read the information stored in the data layer of the disc in a helical or spiral pattern. Problems thus often can be eliminated by merely smoothing the edges of the scratches and/or reducing their width and depth.

5           Repairing optical discs requires a level of control that cannot be consistently achieved by hand. Polishing too aggressively can damage discs. Polishing too delicately leaves them unrepaired. Sandpaper kits are often too aggressive and can make a disc unplayable if too much pressure is applied. Polishing solutions are at the other extreme. They use such fine abrasives to avoid burning that they have  
10           difficulty repairing even moderate scratches - no matter how much pressure is applied.

          The laser disc buffing apparatus disclosed in U.S. Patent No. 5,423,103 uses a polishing technique to remove light and medium scratches and smooth and diminish more severe scratches. The apparatus was designed to repair play side damage using  
15           a radial polishing motion that is much more tolerated by optical disc players. It achieves this radial polishing motion by using a disc-polishing wheel in an orientation that is substantially perpendicular to the disc. It can be a hand-held, manually operated mechanical device or it can be electrically powered.

          Preferably, a buffing apparatus would polish with consistent pressure across  
20           the entire optical disc radius. This control allows the laser disc buffing apparatus to apply the highest pressure short of burning, resulting in the maximum effectiveness that can be achieved without damage to the optical disc.

          It is generally known that when a loop or hoop with thin walls is in the vertical plane and pushed down on a solid, horizontal surface, it exerts a bi-modal force profile  
25           on that surface, with less force exerted directly below the center of the hoop and more force exerted on either side of the center point in the plane of the hoop. Also, it is generally known that when a solid disc in the vertical plane is pushed down on a solid, horizontal surface, it exerts a force on the surface that is a maximum directly below the center of the disc and rolls off on either side of the center in the plane of the disc.

In order to eliminate dust and contaminants from a disc surface, it has been known to use materials such as chamois, mohair, felt or cotton to wipe the surface. It has further been known to fill the scratches by spreading a waxy or other filter material on the disc, then wiping away the excess to repair a damaged disc surface. It has also  
5 been known to use a felt cloth in conjunction with an abrasive solution to buff away scratches on an optical disc.

### **DISCLOSURE OF THE INVENTION**

The present invention overcomes the above problems in efficiently repairing a damaged optical disc by smoothing part of or the entire readable surface of the disc  
10 using an improved buffing wheel in conjunction with a non-abrasive means. The buffing wheel of the present invention overcomes the problems of the prior art by causing the forces between the buffing wheel and the surface of the disc to be substantially uniform so that a substantially flat profile is obtained, thereby facilitating a more uniform buffing of the disc, and allowing a more aggressive abrasive to be used.  
15 Thereafter, the use of a non-abrasive cloth under sufficient pressure over the abrasively buffed area eliminates the need for intermediate abrasive steps and/or reduces the number of abrading steps required to restore the disc to its initial optical reflectivity.

The buffing wheel of the invention may be used in connection with the apparatus of U.S. Patent No. 5,423,103 or with other suitable buffing apparatuses. The buffing  
20 wheel includes a hub, flexible spokes, a flexible outer rim, and a flexible abrasive strip around the periphery of the rim. In operation, an optical disc is mounted in a first plane such as in the apparatus in U.S. Patent 5,423,103. The wheel is then pressed onto the laser readable surface of the disc causing the wheel to partially collapse on and engage the disc under pressure. The flexible spokes of the wheel flex with the wheel rim to  
25 facilitate the exertion of a substantially uniform force over the entire area of the laser readable surface of an optical disc to produce a substantially uniform buffing action. The buffing wheel is then rotated until the damaged area has been suitably buffed to remove the scratch damage and which will cause the generation of substantially radially extending fine scratches. Preferably, the disc is rotated during buffing. A non-abrasive

cloth is then worked over the buffed area preferably in a substantially dry environment using sufficient pressure to generate heat such that the material of the disc flows to substantially remove the fine scratches and substantially restore the optical reflectivity of the disc to its original condition.

5           It is contemplated that the use of the non-abrasive means in a preferably substantially dry environment may also be used separately to clean the disc or eliminate minor scratches from the damaged area of the disc. It is further contemplated that the buffing wheel may be sized for different size optical discs including the compact laser disc, the mini laser disc, and record size video laser disc.

10           Further, it will be appreciated that a plurality of buffing wheels may be used to eliminate or diminish larger scratches in a damaged surface area of the disc.

          It is therefore an object of the present invention to provide an improved buffing wheel for a buffing apparatus that will apply a substantially uniform force across the readable area of a disc when buffing to substantially uniformly buff the area.

15           It is a further object of the present invention to provide an improved buffing wheel with abrasive means to be used in a buffing apparatus that removes or repairs relatively deep scratches or marks from the surface of an optical disc, and to thereafter manually or otherwise buff the surface with a non-abrasive means to substantially remove the fine scratches caused by the abrasive buffing process and restore the optical  
20           reflectivity of the disc substantially to its original condition.

          Another object of the invention is to provide a method of buffing a disc which eliminates the need for intermediate steps to buff out the scratches on a disc and smooth the entire surface of the disc.

25           Another object of this invention is to provide a non-abrasive means in a subsequent buffing step or steps for repairing a disc that smooths out the surface of the disc by generating heat on the surface such that the material on the surface flows to smooth scratches on the surface of the disc.

30           Other objects, features and advantages of the invention will be apparent from the following detailed disclosure, taken in conjunction with the accompanying sheets of drawings, wherein like reference numerals refer to like parts.

**DESCRIPTION OF THE DRAWINGS**

Fig 1. is a front elevational view of the buffing wheel of the present invention;

Fig. 2 is a perspective view of the buffing wheel in contact with the surface of a disc with a damaged area;

5 Fig. 3 is a plan view of a disc following buffing by the buffing wheel and showing the manner of manual buffing with a non-abrasive means according to the invention;

Fig. 4 is a plan view of the disc after the damaged area has been repaired;

10 Fig. 5 is side elevational view of a piece of felt and showing the skiving of the felt;

Fig. 6 is a fragmentary perspective view of another embodiment of the non-abrasive means depicting a piece of felt on a convex section of a spoon-shaped tool; and

15 Fig. 7 is a greatly enlarged cross-sectional view taken through the rim of the wheel and the abrasive material substantially along line 7-7 of Fig. 1 for performing the initial abrasive buffing step.

**DESCRIPTION OF THE INVENTION**

Referring now to the drawings, and particularly to Fig.1, the buffing wheel of the present invention, generally indicated by the numeral 10, is circular in shape and generally includes an annular thin-walled hoop or rim 12 connected to a hub 14 by a plurality of spaced apart spirally shaped spokes 16. Each of the spokes is spirally formed between the hub and rim, such that a degree of flexibility is achieved that will enable a flattened portion of the rim engaging a disc to apply a substantially uniform force along the length of the flattened portion. This action of the wheel is very important in providing uniform buffing across an optical disc. A hole 13 is provided at the center of the hub 14 for mounting the wheel on a shaft, as seen in Fig. 2 and as further explained hereafter.

20  
25

The wheel 10 is preferably molded in one piece by any suitable molding technique from a suitable flexible or pliant material, such as a suitable plastic, like a low-density polyethylene. However, the wheel could be made of any suitable material



and by any suitable method as long as a substantially uniform force result will be obtained when using the wheel against a disc surface to uniformly buff the surface.

Again, for use in a compact disc repair apparatus the wheel rim would preferably have a thickness of about 0.060 inches, a width of about 0.250 inches, and an outer  
5 diameter of about 4 inches.

Preferably, the abrasive material used on the periphery of the wheel will be backed by a strip of foam material. As seen in Figs. 1 and 2, the foam material is designated by the numeral 20, and an abrasive strip 22 is secured to the foam backing 20. Preferably, as shown in Fig. 7, the foam strip will have a coating of pressure-  
10 sensitive adhesive 23 on one side for attaching the strip to the wheel rim and a coating of pressure-sensitive adhesive 25 on the other side to which the abrasive strip 22 will be attached. Any suitable abrasive strip may be used, such as a 4000 grit Micromesh aluminum oxide abrasive made by Micro-Surface Finishing Products, Inc. of Wilton,  
15 Iowa. Micromesh is a trademark owned by Micro-Surface. This abrasive strip includes a woven cloth on which aluminum oxide impregnated latex is cured to provide a buffing surface. Other suitable abrasives may be employed.

Referring now to Fig. 2, the manner of using the buffing wheel 10 to buff a disc 30 is shown. The disc 30 includes a central area 32, a center aperture 34 mountable on a spindle as in the above-mentioned patent, an outer edge 36, and an optical or a laser  
20 readable surface 38 between the central area 32 and the laser readable boundary 39. As shown in FIG. 2, the disc 30 is damaged by scratches 40 which interfere with the readability of the disc. The hub 14 is attached to a laser disc-buffing apparatus (not shown) but which could be like that shown in U.S. Patent No. 5,423,103, the disclosure of which is incorporated by reference. The wheel 10 may be mounted on a suitable  
25 driven shaft 24 and secured in place by a nut 26 or otherwise suitably secured to a shaft or spindle. As the buffing wheel 10 is lowered onto the disc 30, the pliant rim 12 and flexible spokes 16 collapse to define a flattened area or portion on the wheel and cause the wheel 10 to spread out over the entire laser readable surface 38 of the disc between the central area 32 and the outer laser readable boundary 39 adjacent the disc edge 36.  
30 The unique wheel structure creates a substantially flat uniform force profile across the

readable surface 38 of the disc, which facilitates the substantially uniform buffing or polishing of the disc as the wheel is rotatably driven to continually present a flattened profile to the disc. Although Fig. 2 shows the wheel 10 covering the entire readable area of the disc 30, it will be understood that a smaller buffing wheel may be used to only cover a portion of the readable surface 38, if desired. It should be appreciated that the buffing wheel could be employed to buff surfaces other than an optical disc.

To clean or buff a disc, the disc 30 and wheel 10 are preferably simultaneously rotated by the driving means, such as that shown in U.S. Patent No. 5,423,103. It is preferable that the disc 30 rotate at a substantially slower speed than the buffing wheel 10, and preferably at a ratio of about 60 to 1. The wheel rotates preferably in a direction from the outer edge of the disc towards the center of the disc, while the disc may be rotated in either direction. The buffing action on the disc 30 removes material from the readable surface 38 and repairs the surface by eliminating or repairing the scratches 40. Once the disc 30 is satisfactorily buffed, the wheel 10 is taken out of contact from the disc 30 and the disc can be removed for further processing.

Similar to a surface after the application of sand paper, after using the buffing wheel 10, the readable surface of a disc 30 may contain fine or minute scratches 50, as illustrated in the buffed disc of Fig. 3. These scratches resulting from the rotation of the buffing wheel 10 will be substantially uniform scratches extending in a substantially radial, but preferably slightly offset direction on the disc, as shown in Fig. 3. It is understood that different abrasive means may be used in series with each successive abrasive means having finer abrasive material to decrease the size of the scratches on the surface of the disc 30, so long as the non-abrasive means is used to remove the fine scratches remaining from the last abrading step.

Even though the disc 30 may sometimes be read with the presence of small or fine scratches 50, it is preferred to complete the repair process by manually or otherwise buffing the scratches with a non-abrasive material 52. Sufficient pressure is applied to the non-abrasive material 52 over the disc surface to generate heat which causes the material of the plastic layer to flow on a scale that is on the order of the width of scratches left by the previous abrasive step and substantially fill in the fine scratches and

substantially restore the level of optical reflectivity of the disc to its original state and eliminate any interference with the correct reading of the data layer. It should be noted that the non-abrasive means may leave behind some incidental fine scratches, but these will not interfere with reading the disc.

5           Although any suitable non-abrasive material 52 may be used, it has been found that virgin wool felt works well with the present invention. Non-virgin wool may also be used, however, it has been shown that virgin wool is more durable. It has also been found that 100% carbonized wool felt works well, such as Buffalo Felt Products Corp.'s product #1001 C, which has a density of 21.2 lb/cu ft.

10           A particular form of non-abrasive material may be a 1/16 inch thick piece of felt 60 skived, as shown in FIG. 5, from a 1/4 inch piece of felt 62. The skived side 64 of the felt 62 is flat and uniform compared to the non-skived side 66. In application, the skived side 64 is applied against the buffed area 50 of the readable surface with sufficient force to heat the surface and cause the surface material to flow and  
15           substantially eliminate the fine scratches formed by the buffing wheel 10. Any suitably sized piece of felt may be used, preferably in dry form, that can be manually or otherwise applied over the disc surface. This step will then restore the level of optical reflectivity so that the laser beams can accurately read the data layer. Although the felt may be driven in any direction, driving the felt in a direction that is substantially  
20           perpendicular to the scratches works best. It is preferred to use the felt by hand 54, as shown in FIG. 3, but it is also possible to attach the felt to the buffing wheel 10, or to a hand tool, as shown in Fig. 6, or to any suitable type of power tool.

          In an alternative embodiment, as shown in FIG. 6, the felt could be used in connection with a spoon-shaped substantially rigid concavo-convexo shaped hand-held  
25           device or tool 70. A handle may be provided for the tool, if desired. The felt 72 would be attached to the convex face of the device 70 which would then be placed in engagement with the disc for buffing following buffing with the abrasive. Although a device with a convex shape is preferred, other shapes may be employed that will function to facilitate the buffing with a non-abrasive material. For example, a rigid flat  
30           tool with a rim or other structure on one surface could be used, whereby the rim would

provide an enclosure for a user's fingers. In terms of the device 70, a person can place the most central digits of his/her hand inside the curvature 74 on the concave side, apply a suitable pressure, and drive the tool with the felt over the surface of the disk to generate sufficient heat to make the material of the surface flow and substantially  
5 eliminate the fine scratches. It is also contemplated that the felt may be used individually without the abrasive means 22 to repair areas of a disc 30 having minor damage.

It will be understood that modifications and variations may be effected without departing from the scope of the novel concepts of the present invention, and it is  
10 understood that this application is to be limited only by the scope of the appended claims.

## **METHOD AND APPARATUS FOR REPAIRING OPTICAL DISCS**

### **Claims**

The invention is hereby claimed as follows:

1. The method of repairing a damaged area on the surface of an optical disc (30), wherein said surface (38) of said disc (30) includes laser-penetrable material and the damaged area (40) is first buffed in a buffing apparatus with at least one abrasive means (22) and then buffed by an apparatus or by hand with at least one non-abrasive means (52), and wherein the buffing apparatus includes a disc-receiving means (24, 26) and a buffing wheel (10) made of a flexible material and having a hub (14), a flexible annular outer rim (12), a plurality of flexible spokes (16) extending between said hub (14) and rim (12), and an abrasive means (22) around the periphery of said rim(12), and said non-abrasive means includes a piece of cloth (52), said method comprising the steps of:

mounting the disc (30) in said buffing apparatus in a first plane with said surface (38) of said optical disc (30) being exposed,

positioning said buffing wheel (10) in a second plane substantially perpendicular to said first plane and under pressure against said surface (38), whereby said flexible spokes (16) of said buffing wheel (10) and said rim (12) are deformed so that the rim (12) defines a flattened portion in engagement with said disc surface (38) and facilitates a substantially uniform pressure along the area of contact between said buffing wheel (10) and said surface (38),

rotating said buffing wheel (10) such that the abrasive means (22) on the rim(12) removes material from said surface (38) and leaves behind fine scratches (50),

moving said cloth (52) under pressure over the area buffed by the apparatus (50), whereby the action created between said cloth (52) and said surface (38) generates sufficient heat that causes said laser-penetrable material of said surface (38) to flow, smooth the surface (38), and substantially remove said fine scratches (50).

2. The method of Claim 1, wherein said spokes (16) are spirally formed between the hub (14) and rim (12).

3. The method of Claim 1, wherein said abrasive means (22) includes 4000 grit abrasive.

4. The method of Claim 1, wherein the disc (10) is moved under the buffing wheel during the buffing step.

5. The method of Claim 1, wherein the step of moving the cloth (52) is accomplished manually.

6. The method of Claim 1, wherein said cloth (52) is felt.

7. The method of Claim 6, wherein said felt (52) is carbonized wool.

8. The method of Claim 6, wherein said felt (52) is skived from a piece of felt (62) and the skived surface (64) is applied to the disc (10).

9. The method of Claim 1, wherein said abrasive means (22) is foam-backed.
10. The method of Claim 5, wherein said cloth (52) is mounted on a hand-held tool (70).
11. The method of Claim 10, wherein the tool (70) is concavo-convexo and substantially rigid.
12. The method of Claim 10, wherein the tool (70) is spoon-shaped and substantially rigid.
13. A buffing wheel (10) adapted for use in a buffing apparatus having an optical disc driving means for repairing a damaged area (40) on the surface (38) of an optical disc (30), wherein said surface (38) is comprised of a laser-penetrable material, said buffing wheel (10) comprising:
  - a hub (14),
  - a plurality of flexible spokes (16) extending outwardly from said hub (14), and
  - a flexible circular outer rim (12) attached to the outer ends of said spokes (16)and adapted to engage said surface (38),  
whereby the part of said buffing wheel (10) engaging said disc (30) flattens and applies a substantially uniform force across the engaged surface to produce a substantially uniform buffing of the surface.
14. The buffing wheel of Claim 13, wherein said rim (12) extends substantially perpendicular to said spokes (16).
15. The buffing wheel (10) of Claim 14, wherein the spokes (16) are spirally formed between the hub (14) and rim (12).

16. The buffing wheel (10) of Claim 15, wherein the wheel (10) is rotatably driven.

17. The buffing wheel (10) of Claim 13, wherein said buffing wheel (10) further includes an abrasive means (22) around the periphery of said rim (12).

18. The buffing wheel (10) of Claim 17, wherein said abrasive means (22) includes a foam-backed abrasive strip (20).

19. The buffing wheel (10) of Claim 18, wherein the abrasive strip (22) includes a 4000 grit abrasive embedded in latex.

20. The buffing wheel (10) of Claim 19, wherein the abrasive is aluminum oxide.

21. The buffing wheel (10) of Claim 13, wherein the spokes (16) are spirally formed between the hub (14) and rim (12).

22. The buffing wheel (10) of Claim 21, wherein the hub (14), spokes (16) and rim (12) are integral.

23. The buffing wheel (10) of Claim 21, wherein the wheel (10) is molded in one piece.

24. The buffing wheel (10) of Claim 21, wherein the wheel (10) is molded of low-density polyethylene.



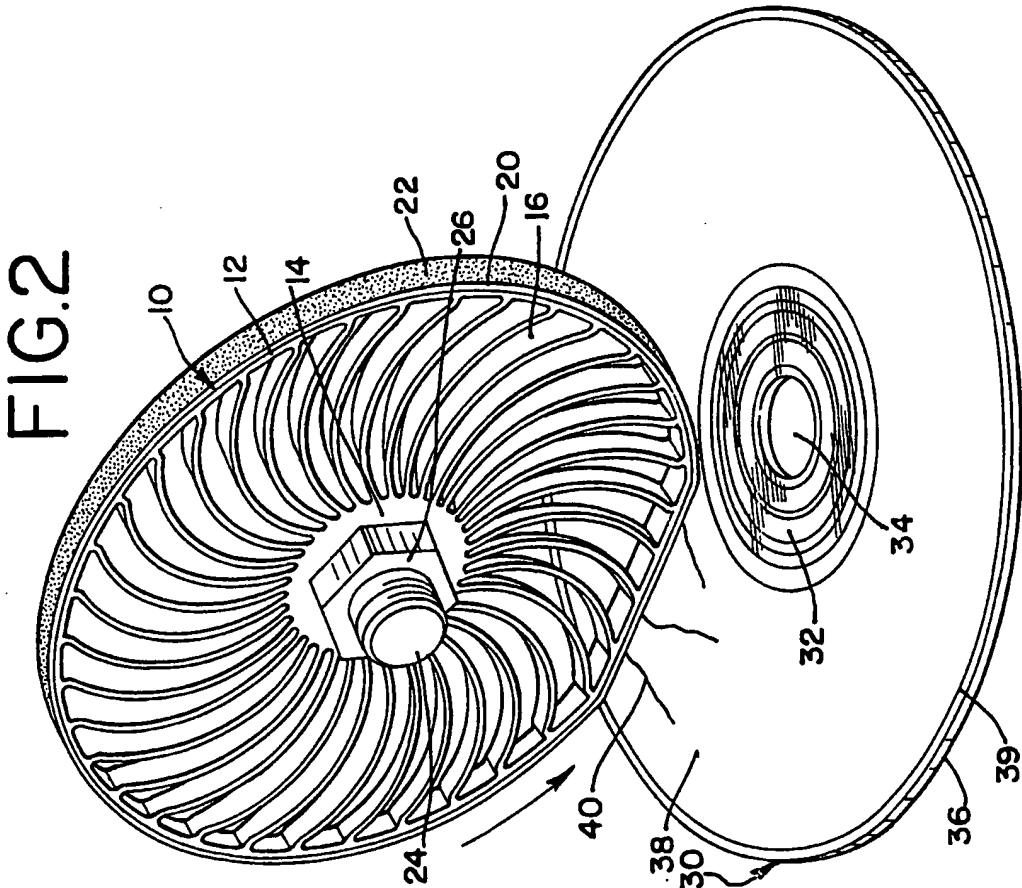
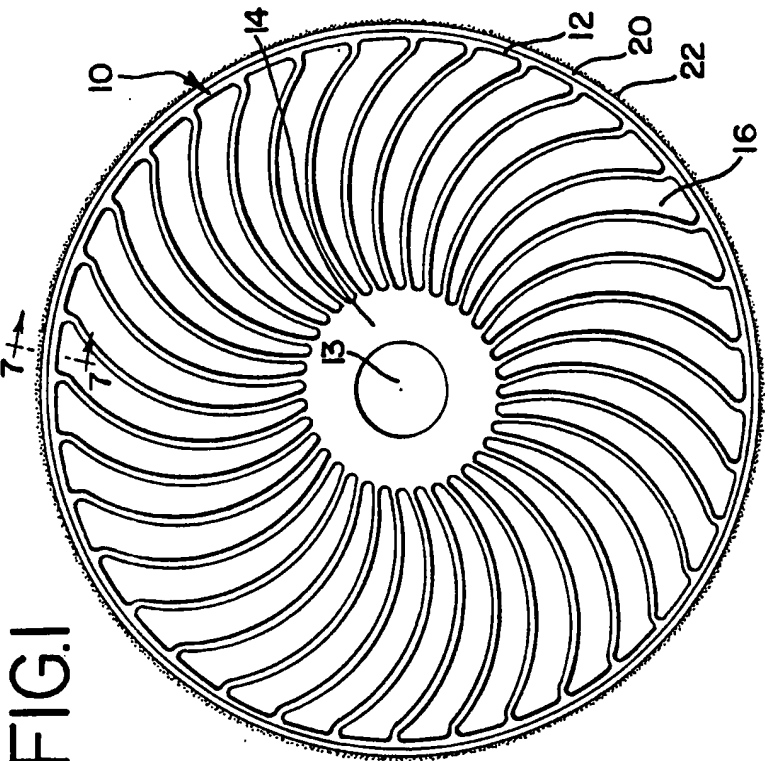
25. A buffing wheel (10) for buffing a substantially flat surface comprising:  
a hub (14) adapted to be mounted on a shaft (24), for rotation therewith,  
a plurality of flexible spokes (16) spirally extending from the hub (14), and  
an outer flexible circular rim (12) connected to the spokes (16) having a buffing  
surface extending substantially perpendicular to the spokes (16) and adapted to have  
mounted thereon an abrasive/buffing material,

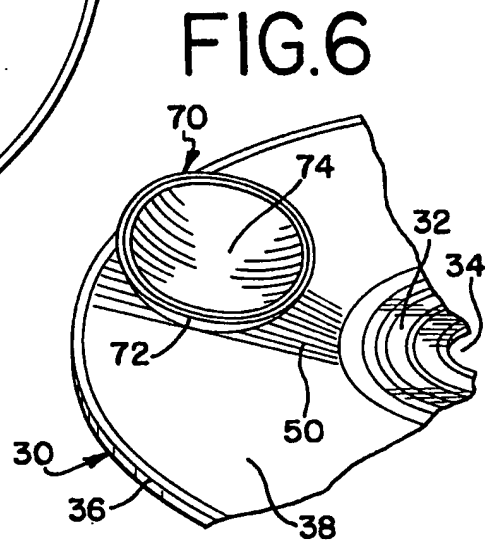
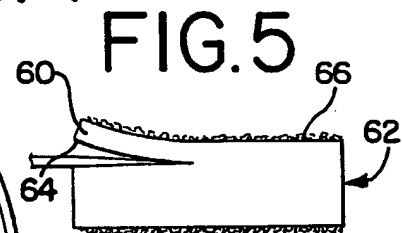
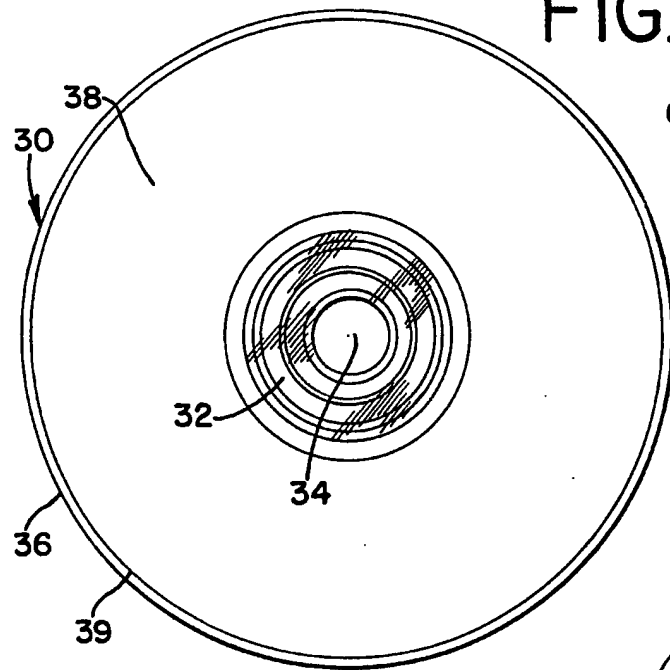
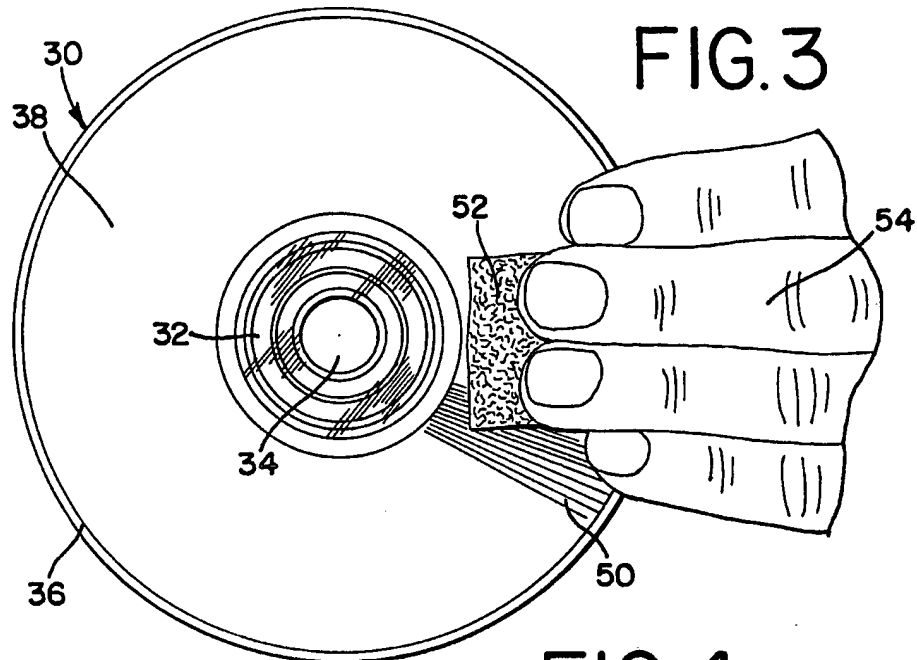
whereby pressing the wheel (10) against a surface (38) to be buffed deforms the  
rim (12) in the area of contact with the surface (38) to define a substantially flattened  
area which applies a substantially uniform force along said flattened area during buffing  
to produce a substantially uniform buffing of the area.

26. The buffing wheel (10) of Claim 25, wherein the wheel (10) is rotatably  
driven.

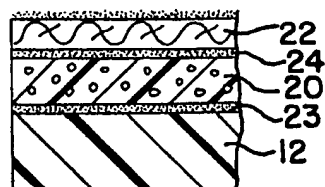
27. The buffing wheel (10) of Claim 26, wherein the hub (14), spokes (16)  
and rim (12) are integral.

28. The buffing wheel (10) of Claim 27, wherein the wheel (10) is molded of  
plastic in one piece.





**FIG. 7**



## INTERNATIONAL SEARCH REPORT

 International application No.  
 PCT/US99/04172
**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(6) : B24B 7/19, 7/30

US CL : 451/63, 526

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 451/63, 526, 28, 57, 490, 508

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,593,343 A (BAUER) 14 January 1997, See Figure 8.	1
A	US 5,733,179 A (BAUER) 31 March 1998, See Figure 8.	1
A	US 5,297,366 A (HUDDLESTON) 29 March 1994, See Figure 1.	1
A	US 5,423,103 A (BORN) 13 June 1995, See Figure 1.	1
A	US 5,292,567 A (FOSTER) 08 March 1994, See col. 3, lines 39-43.	1
A	US 5,101,602 A (HASHIMOTO) 07 April 1992, See Figure 4.	1



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier document published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"G" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

19 MAY 1999

Date of mailing of the international search report

02 JUN 1999

 Name and mailing address of the ISA/US  
 Commissioner of Patents and Trademarks  
 Box PCT  
 Washington, D.C. 20231

Facsimile No. (703) 305-3230

Authorized officer

DERMOTT COOKE

Telephone No. (703) 305-0966

*Shella Veney*  
 Paralegal Specialist  
 Technology Center 3700

## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US99/04172

## C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4,860,611 A (FLANAGAN ET AL.) 29 August 1989, see Figure 1.	1
A	US 4,504,999 A (PEDROTTE) 19 March 1985, See Figure 3.	1
A	US 4,462,036 A (LEONARD ET AL.) 24 July 1984, See Figure 6.	1
A	US 4,451,836 A (LEONARD ET AL.) 29 May 1984, See Figure 6.	1
A	US 4,368,756 A (CARLSON) 18 January 1983, See Figure 2 & 4.	1
A	US 4,365,448 A (WILSON) 28 December 1982, See Figures 1&2.	1
A	US 4,240,483 A (GREGORIC) 23 December 1980, See Figures 2&3.	1
A	US 4,149,294 A (MacKAY, JR., ET AL.) 17 April 1979, See Figure 2.	1
A	US 3,808,753 A (MARAN) 07 May 1974, See Figure 6.	1

**This Page is Inserted by IFW Indexing and Scanning  
Operations and is not part of the Official Record**

**BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ **BLACK BORDERS**
- ☐ **IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- ☒ **FADED TEXT OR DRAWING**
- ☐ **BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- ☐ **SKEWED/SLANTED IMAGES**
- ☐ **COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- ☐ **GRAY SCALE DOCUMENTS**
- ☐ **LINES OR MARKS ON ORIGINAL DOCUMENT**
- ☐ **REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- ☐ **OTHER:** \_\_\_\_\_

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.**